OLLSCOIL NA GAILLIMHE
UNIVERSITY OF GALWAY

Semester 2 Examinations 2023/2024

Course Instance Code(s)	4BCT, 3BP, 4BP, 3BLE, 4BLE, 1OA, 1EM
Exam(s)	B.Sc. (Computer Science & Information Technology), B.E.(Electronic and Computer Engineering), B.E. (Electrical & Electronic Engineering)
Module Code(s)	CT420
Module(s)	Real-Time Systems
Paper No.	1
External Examiner(s)	Dr. Ramona Trestian
Internal Examiner(s)	Prof. Michael Madden *Dr. Jawad Manzoor *Dr. Michael Schukat

Instructions: This exam has two sections:
In section A, Question 1 is compulsory. Answer one other question between Question 2 and Question 3.
In section B, Question 4 is compulsory. Answer one other question between Question 5 and Question 6.

Duration	**2 hours**
No. of Pages	**5**
Discipline(s)	Computer Science
Course Co-ordinator(s)	Dr. Colm O'Riordan

Requirements:

Release in Exam Venue	No[ ]	Yes [☑]
MCQ Answer sheet	No [☑]	Yes [ ]
Handout	No [☑]	Yes [ ]
Formulae & Tables*	No [☑]	Yes [ ]
Cambridge Tables 2nd Edition**	No [☑]	Yes [ ]
Graph Paper*** A4 Graph Paper 1mm 0.1cm Squared (Standard)	No [☑]	Yes [ ]
Other Materials	No [☑]	Yes [ ]
Graphic material in colour	No [ ]	Yes [☑]

End of requirements.

Section A
Answer question 1 and one other question

Question 1 (Compulsory) (20 Marks)

a) Construct the Cyclic Executive (CE) schedule, the Rate-Monotonic (RM) schedule, and the Earliest-Deadline-First (EDF) schedule of the following set of 4 tasks with their respective execution time e_i and period p_i. Review the schedules and comment on their similarities and differences.

Task	e_i	p_i
1	10	50
2	20	100
3	30	150
4	40	200

[10 marks]

b) Implement your CE design in part a) using C-code or pseudo-code. Your solution must be able to detect task overruns, for example because of asynchronous interrupts.

[10 marks]

PTO

Question 2 (10 Marks)

a) Using examples explain the Hamming (7, 4) code with odd parity, highlighting its (single- and double-bit) error detection and (single-bit) error correction capabilities.

[5 marks]

b) Using an example explain the inner working and limitations of Lamport's logical clocks. Further on, expand your example to show why vector clocks provide a better alternative.

[5 marks]

Question 3 (10 Marks)

a) What are the benefits of the Priority Inheritance Protocol and what problem does it solve? Provide an example including diagrams to support your answer.

[5 marks]

b) In PTP, offset and delay calculations benefit hugely from the presence of transparent clocks in the message path.
Using diagrams to support your answer:

- show the message exchange between a master clock, a transparent clock, and a slave clock,
- explain the resulting timestamps and *correctionField* data,
- show the final calculation for either the delay or the offset.

[5 marks]

PTO

Section B
Answer question 4 and one other question

Question 4 (Compulsory) (20 Marks)

a) Describe the impact of latency on soft real-time systems. With the help of a diagram, compare QUIC's connection establishment process to TCP and discuss how it helps in reducing latency for communication.

[7 Marks]

b) Explain how QUIC's multiplexing capability contributes to improving the performance and efficiency by solving the head-of-line blocking issue of TCP.

[5 Marks]

c) Discuss the congestion control in QUIC and analyse how QUIC adapts to network conditions and mitigate congestion effectively in soft real-time systems.

[8 Marks]

Question 5 (10 Marks)

a) What are the limitations of Wireshark in analysing QUIC traffic. Explain the role of QLOG and QVIZ tools in analysing and debugging the QUIC protocol.

[6 Marks]

b) Explain the purpose and functionality of resource waterfalls in performance analysis. How do resource waterfalls help identify performance bottlenecks?

[4 Marks]

PTO

Question 6 (10 Marks)

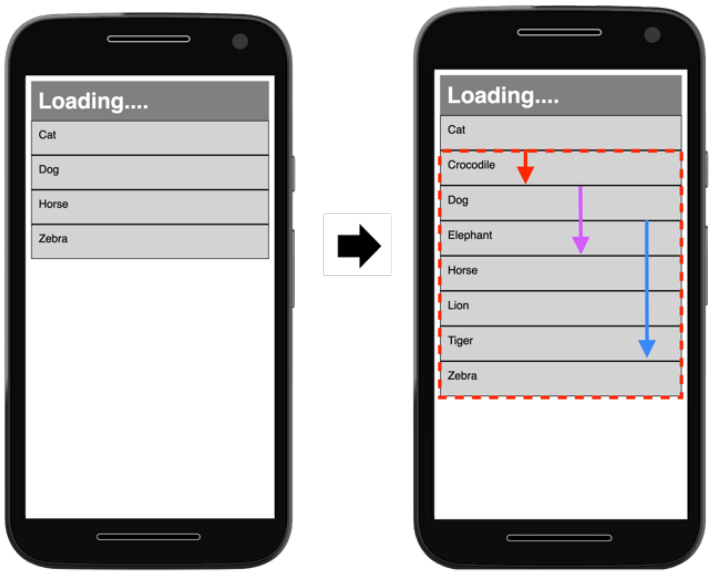
a) Discuss the three Core Web Vitals: Largest Contentful Paint (LCP), First Input Delay (FID), and Cumulative Layout Shift (CLS).

[6 Marks]

b) Evaluate the Cumulative Layout Shift in the following figure to assess its visual stability. During loading, the following layout shifts occur:

- the items labelled "Dog", "Horse", and "Zebra" all shift their start positions, making them unstable elements.
- the red, dotted rectangles represent the union of these three unstable elements' before and after areas, which in this case is around 60% of the viewport's area.
- the “Dog” element has moved by 7.5%, the “horse” element by 15% and the "Zebra" element, represented by the blue arrow, has moved the most, by 30% of the viewport height.

[4 Marks]



END OF EXAM